

Separation of Source Signal from Interfering Signals using Adaptive AMUSE Algorithm

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ABSTRACT— In recent years, blind source separation(BSS) have been implemented in a wide range of applications mainly in signal processing applications. In this paper we proposed to implement the BSS algorithm namely adaptive AMUSE algorithm to the analog circuits, here resistor and capacitor circuit for the separation of source signals from the interfering signals present at the nodes. Design of resistor and capacitor circuit and the Adaptive AMUSE algorithm is applied for the signals obtained. In order to improve the accuracy, a known input signal is taken into account.

Keywords— *blind source separation; adaptive AMUSE algorithm; resistor capacitor circuit;*

I. INTRODUCTION

Blind source separation is a process of separation of source signal from the unknown mixture without knowing the information about the source signal. Classical example is cocktail party problem where a number of people are talking simultaneously in the party hall and one is trying to follow a individual speech. For this human ear is able to unmix the signals and can concentrate on the soul conversation. This is the model of the problem when several signals are present at the input and these signals interfere with other signals in the circuit. Hence BSS comprises the process of blindly recovering the set of unknown original signals. Such a strategy can retrieve any hidden or unknown source signal by simply assuming that each sources are mutually independent.

The application of BSS includes in the acoustic field where we can remove cross talk and separation of speech signal. In the field of bio medical processing for the separation of fetal from electro cardio grams(ECG). In the field of digital communication BSS is used for multi channel equalization and multi user separation. In image processing, for image and video analysis

Interference occurs in the analog circuits, can cause poor performance and high power dissipation. In order to overcome these effects, anti-interference technique is implemented in the circuit. Electro magnetic interference produce noise signals which can be overcome by doing numerical simulation techniques. But this cannot be applicable when the source and interfering signals are unknown. In this paper BSS

algorithm is applicable to the analog circuits for the separation of unknown source signals.

The structure of this paper is as follows: In Section II, Related work is discussed. In Section III, Background for the AMUSE algorithm are discussed. In Section IV, Implemented method is discussed. In Section V, Experiments and discussions are given. In Section VI, the paper is concluded.

II. RELATED WORK

In 2005,A.M.tome et al[1] proposed a an approach called dAMUSE. Here the observed mixed signals are embedded in a high dimensional feature space. Unknown source signals are obtained as filtered versions of Uncorrelated output signals. Weichen et al[2] proposed the AMUSE algorithm for the random signals with the sensors. In 2005,Charayaphan[3] proposed a real time implementation of BSS algorithm. He took three voices and two microphones, but two voices alone separated successfully. The third voice present in both the output signals. S. Chauhan et al[4] proposed a new scheme called Operational Modal Analysis(OMA). It is used for the modal analysis where the dynamic characteristics of the system are identified based only on the output responses . For this BSS techniques are used specially AMUSE. It consumes less time and provides better results. In 2008, J.Taghia et al[5] proposed an approach for the separation of source and noise signals from the observed mixture. It is based on one channel BSS and consists of three stages. In the first stage EMD is used to decompose the observed mixture as a collection of some basis components, then Principal Component Analysis is applied to these IMF's to produce the uncorrelated and dominant basis components. The components obtained are not statistically independent, thus Independent component Analysis is applied. In 2013, Li .Hao et al[6] proposed a instantaneous linear mixing model. He was interested in the separation of source signals from the interfering signals measured at the nodes. In the past decades, source signals are blindly separated, which provides less accuracy. In order to provide better results, he assumed that the sources are statistically independent and a known input signals. In 2014, hasio et al[7] proposed a visual tracking method. Here particle filter implements the Bayesian filter recursively. It maximize

the likelihood of each particle using both mixed and intrinsic images color information.

The structure of this paper is as follows. In section II, Related Work is studied for the understanding purposes. In Section III, Background for the BSS algorithm is discussed to get deep into the proposed algorithm. In Section IV, Proposed algorithm is discussed briefly. In Section V, Simulation results are shown. In Section VI, the paper is concluded with the future work for the enhancements.

III. BACKGROUND FOR AMUSE ALGORITHM

AMUSE (Algorithm for Multiple Unknown Signals Extraction) algorithm[2] is purely a blind identification algorithm under some general conditions. AMUSE Algorithm is as follows:

A. Flowchart for AMUSE algorithm:

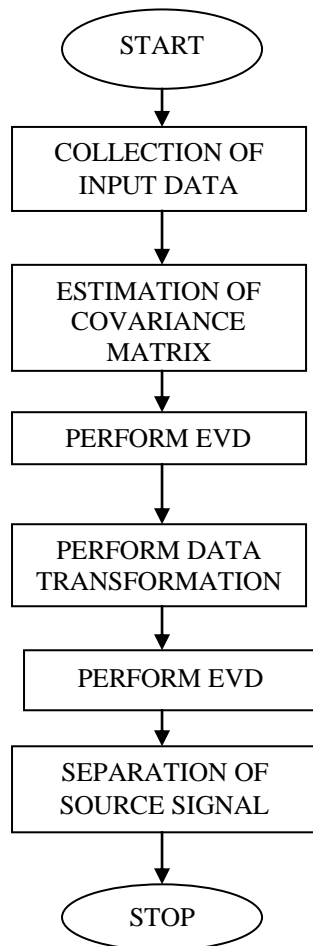


Fig. 1, Flowchart for AMUSE algorithm

- i. Collect the input data.
- ii. Covariance matrix is calculated for the observations.

Where is the covariance matrix at zero time lag and N is the number of sources taken.

- iii. Estimate the Eigen Value Decomposition (EVD) / Singular Value Decomposition (SVD) for the covariance matrix

Where V_s is $m \times n$ matrix of eigen vectors associated with n principal eigen values of $D_s = \text{diag} \{ \lambda_1, \lambda_2, \dots, \lambda_n \}$ in descending order. Where V_n is $m \times (m - n)$ matrix containing $(m - n)$ noise eigen vectors associated with noise eigen values $D_N = \text{diag} \{ \lambda_{n+1}, \lambda_{n+2}, \dots, \lambda_m \}$

- iv. The number of sources n are thus estimated based on n most significant eigen values.
- v. Perform Data transformation
- vi. Estimate covariance matrix for the transformation vector for the specific time lag other than zero time lag. Perform SVD / (EVD in case of eigen values) on the estimated covariance matrix.
- vii. The source signals can be estimated from Eq(7)

AMUSE algorithm performs well since the Singular Value Decomposition ordered the values in the decreasing order. Here Covariance matrix is calculated in order to perform PCA. AMUSE is more advantageous because PCA is applied initially to the data transformation and then to the ordered values of SVD.

IV. IMPLEMENTED METHOD

This paper includes a step by step algorithm for the separation of interfering signals from the original source signals in analog circuits. First of all, it is necessary to implement the analog circuit. Secondly the input signals are given to the circuit. Third step is to select the nodes other than the input nodes randomly. These nodes are taken as the interfering nodes and the signals taken from these nodes are the reference signals. Finally the reference signals are taken from the nodes and the Adaptive AMUSE algorithm is applied for the blind separation of original signal.

A. Flowchart for the separation of source signals

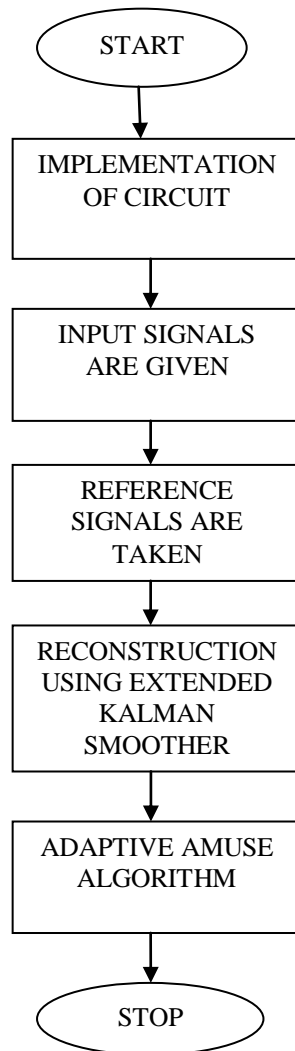


Fig. 2, Flowchart for Adaptive AMUSE algorithm

B. Adaptive AMUSE algorithm:

Generally AMUSE algorithm is a blind identification algorithm which means the term 'blind' refers to the information about the sources. In order to produce the better results, here a known input signal among the number of input signals.

C. Reconstruction using EKS:

a. Kalman filter (KF)

KF consists of two steps. They are Prediction step and update step. In the first step, next step of the system is predicted, given the previous measurement. Secondly current state of the system is estimated, given the measurement at the step. Predicted and estimated state covariances on different time steps do not depend on any measurements, so that they could be calculated off-line before making any measurements. Predict step can

be done by looping, but accuracy of estimate decreases. Recursion in this filter moves only in the forward direction. Kalman Smoother (KS) performs recursion in backward direction also.

b. Extended kalman filter (EKF):

EKF extends the scope of kalman filter to nonlinear optimal filtering problems by forming a Gaussian approximation to joint distribution of state X and measurements Y using a taylor series based transformation. EKS combines the term EKF and KS.

D. Separation of source signals.

Once the reference signals are obtained, adaptive AMUSE algorithm is applied to a known input signal and the reference signals. Next the reconstruction of these signals using Extended kalman smoother is done to provide the better results.

V. EXPERIMENTS AND DISCUSSION

Resistor and capacitor circuit:

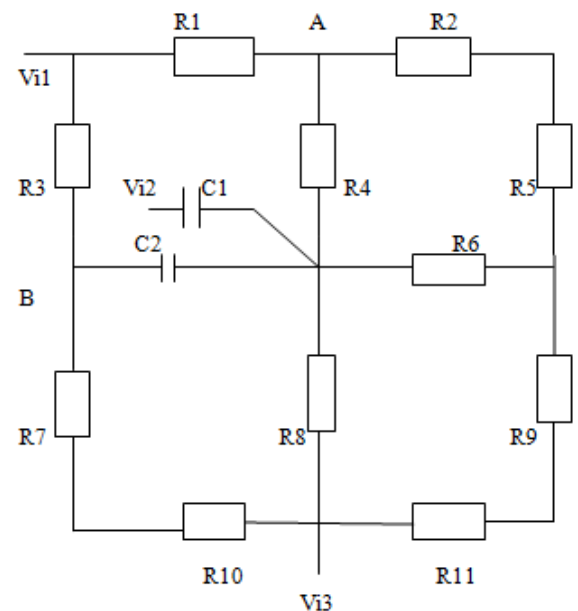


Fig. 3, Resistor and capacitor circuit

The above circuit is designed using SIMULINK. Resistor and Capacitor are the only passive components present in the circuit. Resistance value ranges upto 70k . Capacitance value ranges upto nF. Here Vi1 is given a sinusoidal signal. Vi2 is sawtooth signal, Vi3 is pulse signal. Randomly selected nodes are A, B and C. The reference signals are taken from these nodes. At first, the AMUSE algorithm using MATLAB R2013a is applied to the reference signal to recover the source signal. The recovered signal are less accurate. In order to improve the accuracy, a known input signal is taken into account in addition to the reference signals to recover the source signal. Hence

Adaptive AMUSE algorithm is applied to the source and interfering signals. The following figures, Fig. 1, Fig. 2 and Fig. 3 represents the input signals at Vi1, Vi2 and Vi3.

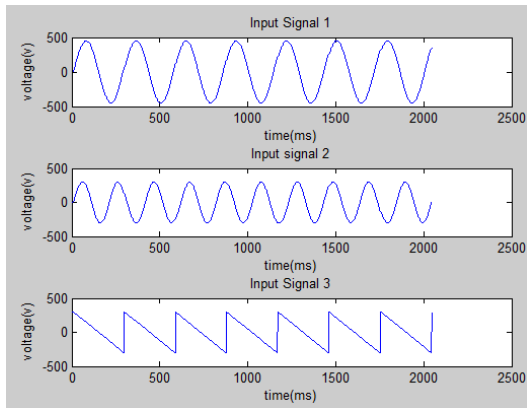


Fig. 4, Input signals

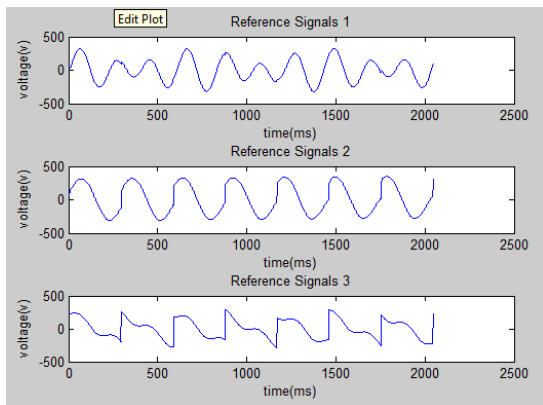


Fig. 5, Reference signals

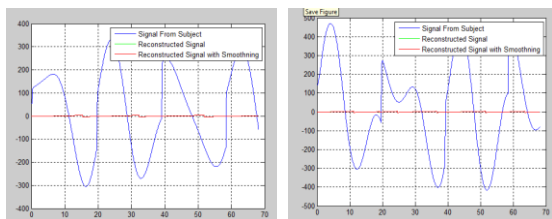


Fig. 6(a)

Fig. 6(b)

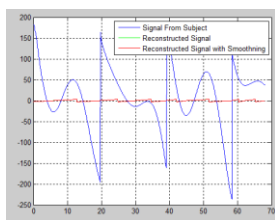


Fig. 6(c)

Fig. 6, Reconstruction of Signals for AMUSE algorithm

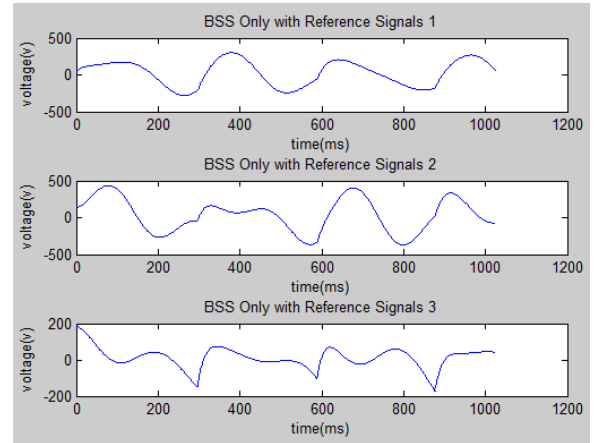


Fig. 7, Separated signal using AMUSE algorithm

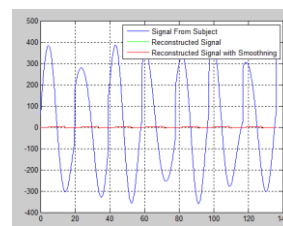


Fig. 8(a)

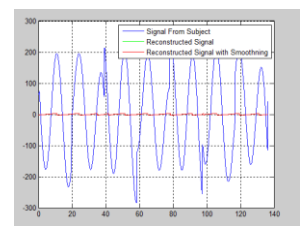


Fig. 8(b)

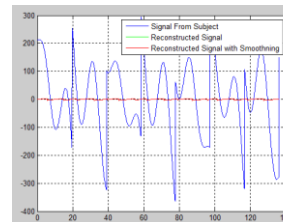


Fig. 8(c)

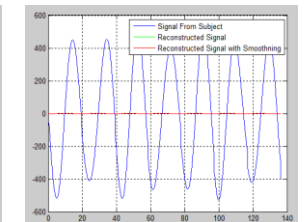


Fig. 8(d)

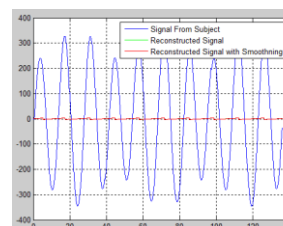


Fig. 8(e)

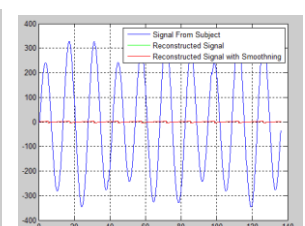


Fig. 8(f)

Fig. 8, Reconstruction of Signals for Adaptive AMUSE algorithm

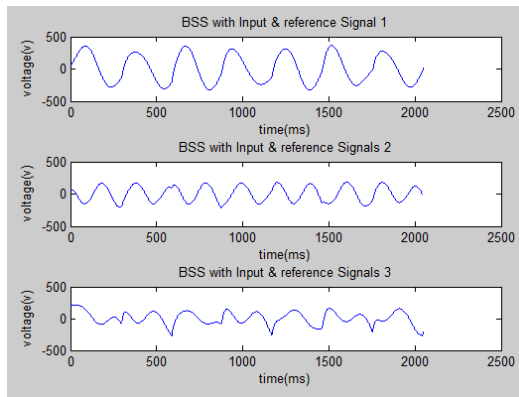


Fig. 9, Separated signal using Adaptive AMUSE algorithm

From the above figures, while comparing the output signal obtained from the application of AMUSE algorithm with output signal obtained from the application of Adaptive AMUSE algorithm, our algorithm produces better results.

VI. CONCLUSION

Hence the Resistor and Capacitor circuit for the separation of source signals from the interfering signals present at the nodes. Design of the circuit using Simulink and the application of the Adaptive AMUSE algorithm produces better results when compared to AMUSE algorithm. From the AMUSE algorithm accuracy is improved from a known input signal is taken into account. In order to obtain further accuracy, it requires some more enhancements.

REFERENCES

- [1] A.M. Tomé , A.R. Teixeira, E.W. Langb, K. Stadlthanner,A.P. Rocha c, R. Almeida “dAMUSE—A new tool for denoising and blind source separation”. Digital Signal Processing 15 (2005) 400–421.
- [2] Weichen LIU ,Chong-Yung CHI, “Research In AMUSE: A Blind Identification Algorithm”.
- [3] C. Charoensak and F. Sattar, “Design of Low-Cost FPGA Hardware for Real-time ICA-Based Blind Source Separation Algorithm”. EURASIP Journal on Applied Signal Processing 2005:18, 3076–3086.
- [4] S. Chauhan, R.J. Allemang, R. Martell, D.L. Brown, “Application of Independent Component Analysis and Blind Source Separation Techniques to Operational Modal Analysis”.
- [5] J. Taghia, M. H. Savoj, “Noise separation in analog integrated circuits using EMD-PCA-ICA”.16th European Signal Processing Conference (EUSIPCO 2008), Lausanne, Switzerland, August 25-29, 2008.
- [6] Li Hao1, Chen Zhiyong1, Zhang Ruixue2, Dong Yonggui1, “Blind Source Separation of Interfering Signals in Analog Circuits” 22nd International Conference on Measurement, Information and Control-2013.

- [7] Hsiao-Tzu Chen and Chih-Wei Tang, “visual tracking using Blind source separation for mixed images”,IEEE International Conference on Acoustic, Speech and Signal Processing (ICASSP)-2014.
- [8] Jouni Hartikainen, Arno Solin, and Simo Särkkä, “Optimal Filtering with Kalman Filters and Smoothers”.